Variability of the ozone field in the TTL observed by the DIAL and CAFS instruments during the TC4

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DC-8 at San Jose airport ready to fly on July 22, 2007

In the summer of 2007 the NASA DC8 aircraft took part in the Tropical Composition, Clouds and Climate Coupling (TC4) campaign based in Costa Rica. Multiple in-situ and remote-sensing instruments aboard the aircraft were set to measure atmospheric composition of the tropical tropopause layer (TTL). The partial ozone column above the aircraft products were derived from the CCD Actinic Flux Spectrometer (CAFS) instrument (R. Shetter, NCAR) measurements as part of the continuous validation of the Aura ozone products. Both the combined stratospheric ozone columns derived from the CAFS measurements and the Differential Airborne Lidar (DIAL) ozone profile measurements aboard the NASA DC8 aircraft detected ozone variability in the TTL. We present analysis of the in-situ aircraft data and the data above the aircraft with regards to the TTL properties influenced by both slow ascent and by rapid transport in the deep convection conditions. The transport trajectories and correlated measurements of the water vapor and other boundary layer tracers are used in the ozone field analysis.

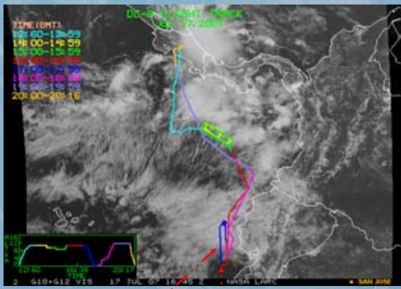


Figure 1. RTTM GOES visible image and DC-8 flight tracks on July 17, 2007 flight.

Depleted ozone episode

- Observed at the South most point of the flight.
- DC-8 was in and out of the depressed ozone field
- DIAL ozone mixing ratio profiles are available below and above DC-8 flight level
- Matching low ozone in both DIAL and CAFS data
- Match OMI to DC-8 flight tracks to less than 5 degrees difference in longitude

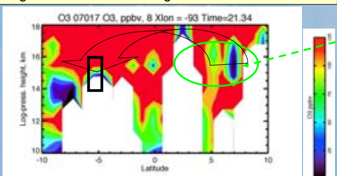


Figure A HIRDLS ozone profile latitude cross section along the DC-8 tracks, at ~83 W. Green circle indicates the deep convections at ~ 5-10 N, and black square points to the depleted ozone event.

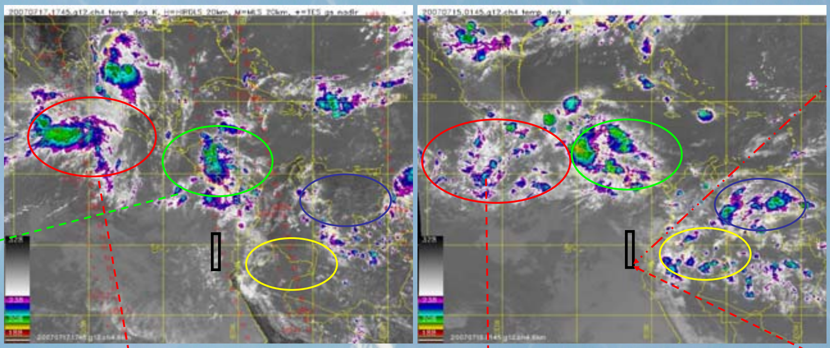


Figure 3. GOES Ch.4 temperature images at two time periods: on July 17(left) and 15 (right), 2007. The black rectangle identifies location of the DC-8 between 16:30 and 17:30 UT on July 17, 2007. Notice the similarity in location of deep convection systems (inside of the red circles) between two periods of time. Yellow ovals indicate the location of the systems close to the location of the DC-8 at the south-most part of the track. Aura overpass (red symbols on the left plot) is at ~19:00 UT.

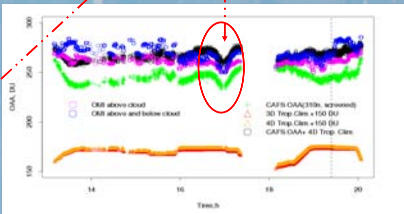


Figure 2. Depleted ozone column above aircraft at about 17 UT. CAFS ozone column data above aircraft (green) and ozone climatology (orange) are combined to make a total ozone column (black symbols). The depleted episode matches similar reduction in OMI-TOMS v2 ozone column (blue and magenta)

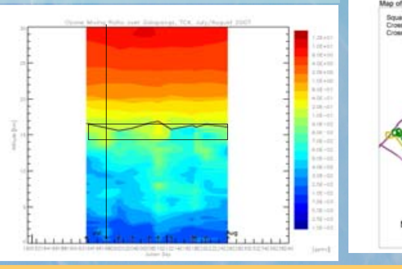


Figure B. Contour plot of ozone sounding launched from Galapagos Islands during the TC4 campaignperiod of time (courtesy of H. Vomel). Vertical black line indicates July 17, 2007 event, black rectangle indicates altitude of depleted ozone observed DC-8 DIAL data on July 17, 2007. Depleted levels of ozone seems to appear in ozone sonde data and likely associated with deep convection events.

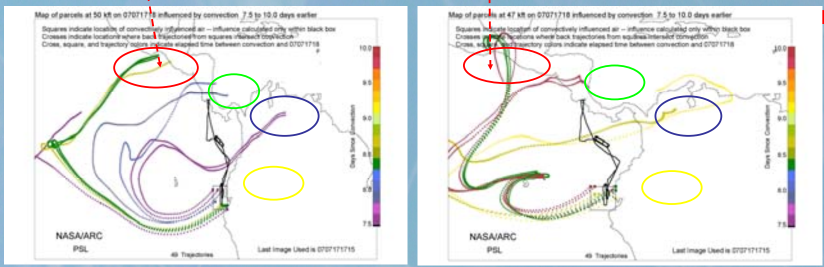


Figure 4. Back trajectories (adiabatic) at 50 Kft (left) and 47 Kft (ight) altitude were ran for 10 days from a 1 by 1 grid of points denoted by the black squares (courtesy of L. Pfister, NASA/ARC). The colors are the days since the convection. The black rectangle identifies location of the DC-8 between 16:30 and 17:30 UT on July 17, 2007. Notice that most of the trajectories go south and then west initially (as time decreases), but curl around and head north toward the convective regions (see red circles in Figure 3 above).

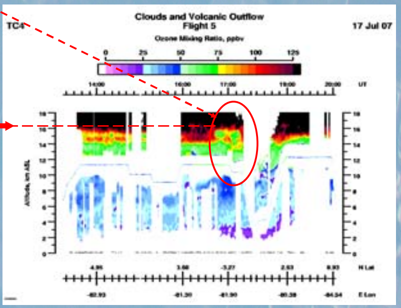


Figure 5. Ozone profiles derived by the DIAL instrument on board the NASA DC-8 flight on July 17, 2007 as function of altitude and time. The depleted ozone layer between ~14 and 16 km is marked with red oval.

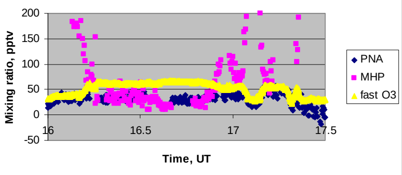
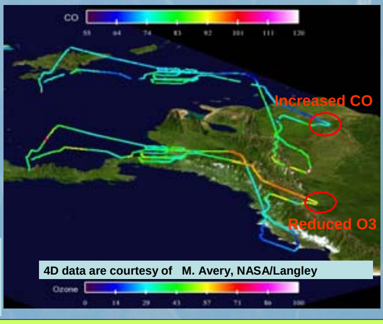


Figure 7. **PNA (horizontal transport)** and **MHP (vertical transport)** tracers (measured by CIMS team), and in-situ ozone (M. Avery, NASA/Langley) mixing ratio are measured at the altitude of the DC-8 aircraft (see figure to the right).



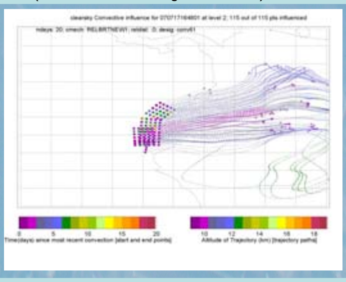


Figure 8 (above). According to the trajectory analyses at the aircraft level (courtesy of L. Pfister, NASA/Ames), perturbed ozone mixing rations (from Melody Avery in situ measurements) may be related to the Eastern Amazon region (biomass burning).

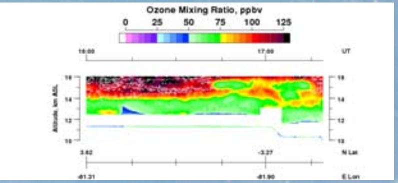


Figure 6. Contour overlays of the infrared aerosol scattering ratio on top of the ozone field (courtesy of Marta Fenn, DIAL NASA/Langley). The higher aerosol scattering is associated with high ozone, and the low ozone occurs in the absence of aerosols. Presence of aerosols along with elevated ozone levels between 14 and 16 km is a possible sign of the aged air mass. Absence of aerosols at location of depleted ozone at 17 UT between 14-16 km altitude (green circular features in DIAL ozone field) might mean that it is a freshly pumped up air-mass.

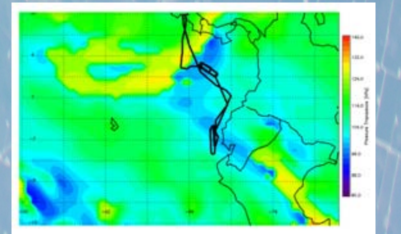


Figure 9 (right). 3-hours averages of tropopause pressure maps for the July 17 flight. The WMO tropopause definition (2K criteria) is used in NCEP analysis. Modulations of the tropopause pressures seems to propagate from the north-west and lifts tropopause height near Ecuador coast.

Results of the TC4 campaign

- 14-16 km is TTL (transitional layer) with tropopause at ~16 km. It is characterized by low temperatures. The TTL is typically not perturbed by convection (does not reach above 14 km), so ozone builds up in the TTL (red color in DIAL data).
- Below 14 km ozone is lower because it is influenced by convection that pumps low ozone from the boundary level (green color in DIAL data).
- Based on the back trajectories, the convective influence in the south part of the flight most likely came from Pacific convection, whereas further north it was mostly either Caribbean convection or South American.
- Presence of aerosols along with elevated ozone levels between 14 and 16 km is a possible sign of the aged air mass.
- Absence of aerosols at location of reduced ozone at 17 UT between 14-16 km altitude (green circle features in DIAL ozone field) might mean that it is a new freshly pump up air mass.
- There seems to be difference in direction of trajectories derived below (Fig.8, South America) and above (Fig. 4 Pacific coast of Mexico) the aircraft. Therefore, ozone depletion above the aircraft and elevated/reduced ozone mixing ratios at the aircraft level, and increased ozone below the aircraft are governed by different processes.

CAFS, DIAL, FASTOZ, CIMS data are available from the ESPO NASA archive at http://espoarchive.nasa.gov/archive/arcs/tc4/docs/dataproducts.html. OMI data are available from the Aura Validation Center Archive GSFC DAAC at http://avdc.gsfc.nasa.gov. The HIRDLS Version 004 Level 2 Data were made available from the NASA GSFC archive http://disc.gsfc.nasa.gov/Aura/HIRDLS/index.shtml.
Coupled convective influence analysis trajectories and GOES satellite images are performed by L. Pfister (NASA/Ames) at http://bocachica.arc.nasa.gov/TC4_meteorology/TC4_met.html. The NASA DC-8 forward and nadir camera movies are available from the NSERC archive http://archive.nserc.und.edu/